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Effect of climate change on four species of Azteca in Monteverde, Puntarenas, Costa Rica

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Microhabitat use and escape behavior of male, female and juvenile Norops oxylophus (Polychrotidae)

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ABSTRACT

The intraspecific distributions of microhabitats in territorial lizard species is determined largely by differing behavior among sexes and age classes. In this project I study a population of *Norops oxylophus* along the Río Alondra of the San Luis Valley towards the end of the rainy season. I caught individuals, recording their age, sex, size, perch substrate and location, and escape method. I found that adult males prefer to be perched on live tree branches overhanging the water; the larger the individual, the higher he is above the stream. Juveniles are found to inhabit lower areas along the stream banks. Males mean vertical perch height was 123cm and juveniles were 58cm. Females are found to vary dramatically in location, however are most common in live trees overhanging the water. Male territoriality affects the distribution of juveniles, but not females, because territory is primarily for maintaining exclusive access to females. Male, female and juvenile escape behavior differs depending on where they are found because of differences in ecological and reproductive interests.

RESUMEN

Las distribuciones intraespecífica de los microhabitats en especies de lagartijas territoriales se determinaron en gran parte diferenciando el comportamiento entre sexos y clases de edades. En este proyecto estudie una población de *Norops oxylophus* a lo largo del Rio Alondra en el Valle de San Luis al final de la estación lluviosa. Capturé individuos, registrando sus edades, sexos, tamaño, sustrato y ubicación de la percha y método de escape. Encontré que los adultos machos prefieren tener la percha en ramas de árboles vivos encima del agua, entre más grandes el individuo, más alto se encuentra encima de la cebrada. Los juveniles se encontraron viviendo en áreas más bajas a lo largo de los lados de la cebrada. La altura promedio de percha vertical para los machos fue 123cm y para los juveniles fue 58cm. Se encontró que las hembras varían dramáticamente en ubicación, no obstante son más comunes en árboles vivos encima del agua. La territorialidad de los machos afecta la distribución de los juveniles, pero no la de las hembras, porque el territorio es primariamente para mantener acceso exclusivo a las hembras. El comportamiento de escape de machos, hembras y juveniles se diferencia dependiendo de dónde se encuentran debido a diferencias en intereses ecológicos y reproductivos.

INTRODUCTION

Costa Rica harbors 27 of the 650 species of slender-bodied lizards in the Cosmopolitan family Polychrotidae (Leenders, 2001). Most species in this family are in the extraordinarily diverse genus *Norops*. Collectively, the 21 species of *Norops* in Costa Rica occur in almost every terrestrial habitat in this tropical country (Savage, 2002). All members in this genus have broadly expanded toes and fingers ending in a narrow toe and claw, making them good climbers (Leenders, 2001). All species of Norops lay eggs, and most lay one egg every few weeks (Leenders, 2001). Males *Norops* are usually larger than females and they invariably possess extendable, usually colorful skin flaps on their throat, called dewlaps. All male anoles in Costa Rica are territorial and flash their dewlap in territorial competition as well as courtship behavior (Savage, 2002).

Norops oxylophus is unusual in that it is semiaquatic, living in the riparian habitats of Costa Rica, Nicaragua and Panama, below 1150m (Leenders, 2001). Preferred perch substrates of this anole are boulders, fallen logs and piles of stream drift (Fitch and Corn, 1981). In this riparian habitat, they forage mostly on arthropods, but occasionally eat small fish (Leenders, 2001).

While some aspects of the natural history of *Norops oxylophus* are known, little is known about microhabitat use by adult males, adult females and juveniles. Several studies of nearby populations of *Norops* spp. indicate fine-scale partitioning (use) of perch heights and substrates. Male individuals of *N. humilis, N. tropidolepis, N. woodi, N. altae* and *N. intermedius* were found to be active higher above ground than females, which averaged higher than juveniles (Pounds, 1988). The same may be true of *N. oxylophus.* This study hopes to explore microhabitat use between the sexes and classes of *N. oxylophus*.

Another interesting aspect about which virtually nothing is known is the use of water and other substrates for escape by *Norops oxylophus*. *N. Oxylophus* is known to escape by jumping into the stream current and swimming underwater, appearing again downstream (Leenders, 2001). Different escape methods have certain risk or advantages depending on the age and sex of the individual. This risks and advantages revolve around microhabitat partitioning and thus deserve closer attention. Here, I investigate sex and age differences in the propensity for water escapes in *N. oxylophus*.

MATERIALS AND METHODS

The study was conducted in the tropical premontane moist forest (Zone 1) of the upper San Luis Valley, Costa Rica, 1150m in elevation (Holdridge, 1967). The study site was the first 2-3km of the Rio Alondra, above the Ecolodge San Luis Road. Rio Alondra is a small creek (approximately 2-3m wide) running through pastures and secondary forest. Vegetation surrounding the creek can be summarized as small trees, vines, tall reeds, and woody or herbaceous shrubs growing above and around the rock studded banks. Many piles of stream debris have accumulated on and around fallen trees.

I collected data only from visible substrates that could be seen from the stream bank. Upon sighting individuals I first determined if the individual was adult or juvenile. All *N. oxylophus* visually estimated as smaller than 4cm were assumed juvenile and all larger than 4cm were assumed to be adult. I then recorded the substrate that the *N. oxylophus* were perched on (Table 1).

Table 1:	**Definitions and descriptions of perch substrate categories**
Dead tree	Dead logs on bank or over stream and all their parts; dead trees still standing and all their parts (excluding roots)
Live tree	All live trees, and shrubs and all their parts
Roots/Vines/Reeds	All vines and roots protruding and hanging around the Bank; reeds near or over stream and the parts of all of these
Rocks/Dirt	All Rocks in middle of stream or on bank; grounds In between rocks including bank wall

I caught the adult individuals and determined sex by checking for a dewlap and then I measured the snout vent length to the nearest 0.1cm of each using a tape measure. Then, the adult individual was replaced on it original substrate, where I recorded its method of escape (Table 2). The juveniles were not captured and thus not sexed or measured. I recorded juvenile escape methods by moving towards an individual, feigning an attempt to capture it and then recording its response. Lastly, I measured the horizontal and vertical distance in centimeters of the original perch substrate relative to the stream. For horizontal measurements, all perch substrates over the stream were considered positive and all over the bank negative, thus the stream-bank interface is considered 0cm.

Table 2:	**Definitions and descriptions of Escape methods**
Immediate water escape	All escapes in which every action taken by the Norops is to made to reach the stream
Delayed water escape	All escapes eventually ending in reaching the water, but with additional actions or hesitations in the process
Ground escape	All escapes in which the Norops run to or along the ground/bank, away from the stream
Crevices escape	All escapes in which the Norops goes to cracks or crevices of on the ground. In this escape the Norops makes no attempt to move either into or away from the river. It is hiding.
Same Substrate escape	All escapes in which the Norops stays on the substrate where it was caught. It can move out of reach, jump between branches, hide or simply stay when replaced, but it does not change substrates.

To address questions concerning distribution patterns, I analyzed perch preference data with lizard type (males, females and juveniles) using unpaired t-tests. To analyze perch substrate data, I used a Chi-squared test. To see if *Norops oxylophus* size affects their perch position, I used simple regressions. To address questions concerning *Norops* *oxylophus* behavior and the effects of microhabitat on behavior, I compared lizard type, escape methods and perch substrate, using Chi-squared tests.

RESULTS

Adult vertical perch position significantly differed from juveniles ($t = -4.282$; $P = < 0.0001$ and $t = 2.573$; $P = 0.0132$ respectively). Male mean average perch height was however higher than female which was higher than juvenile (Table 3). Male horizontal perch differed significantly from juveniles ($t = -2.381$; $P = 0.0208$; see table # 1 for mean values). Females did not differ in horizontal perch from males or juveniles. Females are more variable in their perch position than males and juveniles (Table 3).

Table 3. *Mean Vertical and Horizontal Perch Positions, and Vertical and horizontal variance of Lizard Type*

Table 3.	Males	Females	Juveniles
Mean vertical perch position	123cm	107cm	58cm
Mean horizontal perch position	36cm	32cm	(-) 20cm
Vertical Variance (S^2)	5847	3546	2960
Horizontal Variance (S^2)	12379	8653	6623

Chi-squared results for lizard type and their substrate preference showed that substrate preference varies with lizard type (Chi-squared = 13.47; df = 6; $P < 0.05$). All lizard types prefer live trees as a substrate (Figure 1).

Males and females differed in mean snout vent length (7.78cm and 5.89cm respectively) by 1.89cm. There was a positive correlation with male size and vertical perch position ($t = 3.682$; $P = 0.0010$; $R^2 = 0.326$) (Figure 2).

The escape method of each lizard type significantly differed from one another (Chi-squared = 28.55; df = 8; $P < 0.05$). Females and juveniles preferred immediate water escape (approximately 57% of female and juvenile individuals), and males preferred the ground escape (36.67% of male individuals) (Figure 3).

The escape method that juveniles' use depends nonrandomly on the substrate they are on when a predator approaches them (Chi-squared = 45.95; df = 12; $P < 0.05$) (Figure 4). They use water most frequently, especially when starting from either rocks or live trees. Adults (males and females collectively) however, data does not support his support this (Chi-squared = 3.741; df = 12; $P > 0.05$) (Figure 5).

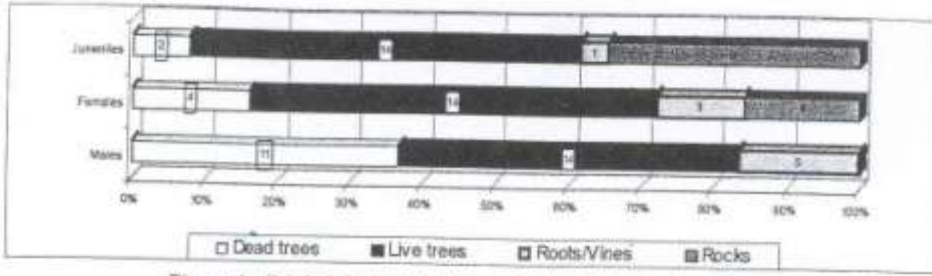

Figure 1. *Perch Substrate Preference of Lizard Type by juveniles (total n=26), females (total n=25), and males (n=30). Frequency of occurrence for each substrate is noted inside substrate type.*

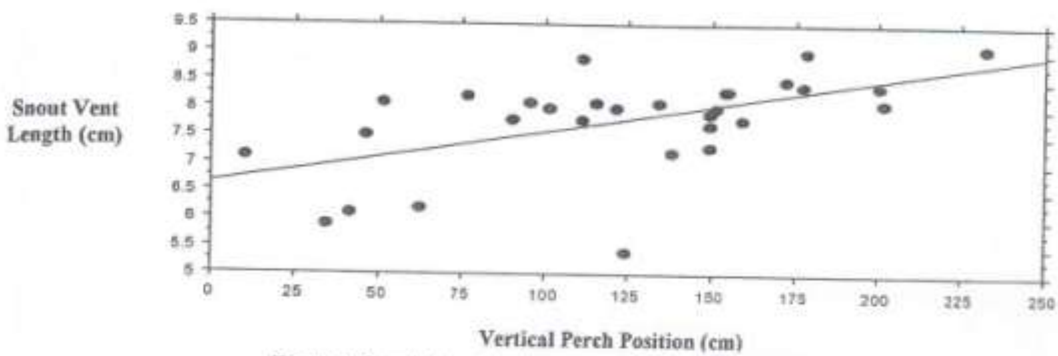

Figure 2. Correlation of male snout vent length and vertical perch position

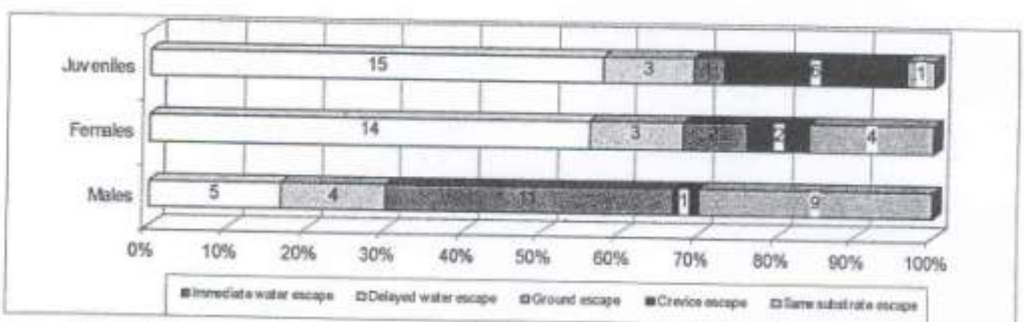

Figure 3. *Displays the Escape Preference of each Lizard Type by juveniles (total n=26), females (total n=25), and males (n=30). Frequency of occurrence for each substrate is noted inside substrate type.*

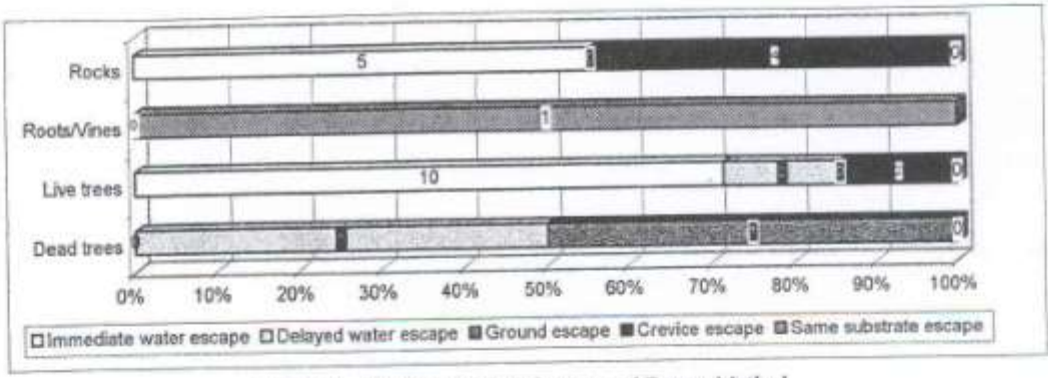

Figure 4. *Juvenile Perch Substrate and Escape Method*

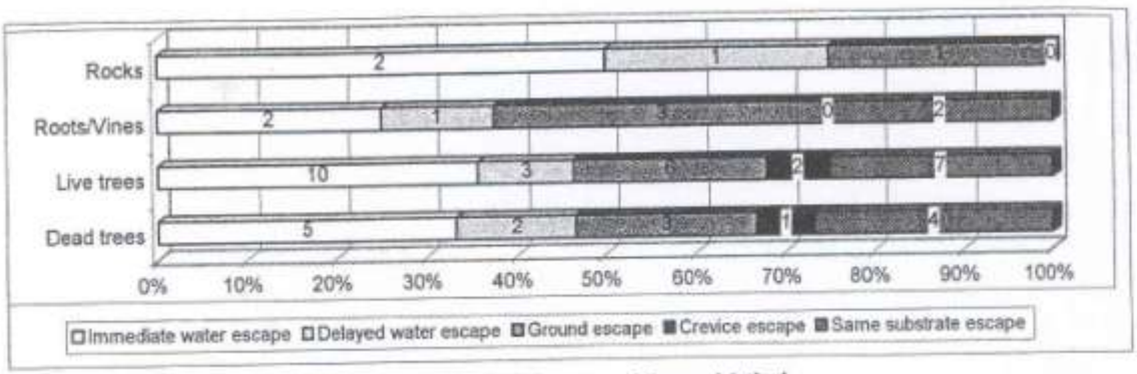

Figure 5. *Adult Perch Substrate and Escape Method*

DISCUSSION

Niche Partitioning by Males, Females and Juveniles

Supporting the idea that there is intra-specific niche partitioning, the results show that adults and juveniles differ in perch heights (Table 3) and that males, females, and juveniles all differ in their substrate type (Figure 1). While adult males and females have similar perch positions, both vertically and horizontally (although females are much more variable than males), they seem to prefer different substrates. Males preferred perching in both live and dead trees, while females tended to prefer only live trees. Juveniles on the other hand tend to be quite low to the ground, perching on live trees as well as rocks.

The reasons behind these differences may revolve around the different ecological and reproductive needs that males, females and juveniles experience. Juveniles must avoid predators and competition from adult males in order to grow to reproductive age. Being on the ground may keep juveniles away from adult males territoriality and safe from predators. Being close to the ground may also give juveniles access to terrestrial arthropods that are not available higher in the vegetation (Savage, 2002). Females, on the other hand, need to avoid predators and feed as much as possible in order to satisfy the energy requirements of laying an egg every few weeks (Leenders, 2001). Having a larger range of foraging grounds may give females a greater variety of food. Lastly, adult males have a primary interest in maintaining their territory for access to food and mates (Andrews, 1983). Their choice of relatively higher perches suggests that surveying their territory and mate-acquisition is more favorable at greater heights. The trend for larger males to hold higher territories suggests that larger males have a competitive advantage in male-male territorial disputes that may lead to larger territories. Higher perches make better vantage points than lower ones (Andrews, 1983); therefore, larger males may perch higher than smaller ones to improve vision for spotting mates and competitors, making up for their relatively larger territories.

Escape Behavior

A major finding of this study is that water escapes for *Norops oxylophus* are common (23% of total escapes), especially among juveniles and adult females (> 56% of juveniles and adult female escapes) (Figure 3). While the type of substrate preceding the attack seems irrelevant to the escape behavior of adult males and females (Figure 5), juveniles tend to rely primarily on water escapes if they are on live trees or rocks at the moment of attack (Figure 4). Juveniles tend to rely secondarily on crevice escapes when on live trees and rocks.

The reluctance of adult males to use water escapes (17% of male escapes) may be related to the potential dangers of being absent in a territory. Adult male *N. oxylophus* have more to lose by jumping in the steam and being swept away. They stand to lose their territory and the females within their territories to neighboring males. In several species of *Norops*, males have been known to increase their territories with the absence of neighboring males (Andrews, 1983). The same may be true of male *N. oxylophus,* explaining their tendency to use ground escapes (> 36% of male escapes) and same substrate escapes (30% of male escapes). By contrast, juveniles and adult females risk no major losses being swept downstream and relocating. Females that appear in a new area are unlikely to experience intra specific competition because they are welcomed into male territories. Juveniles can simply stay near to the ground in a new area, competing with the occasional conspecific juvenile or adult female, as was normal in their previous location.

In addition to territorial risks limiting the choices of escape methods, anatomical characteristics such as body size may also play a role (Pounds, 1988). For instance, juveniles used crevice escapes more frequently than adults (> 23% of juvenile escapes). The smaller body size of juveniles may allow them easier entry to safe havens in tiny cracks that adults could not fit in. Supporting this idea are the numbers of adults, or lack thereof, using this escape. While adult males (the largest individuals) were not observed using the crevice escape, females (smaller than males) did use this escape (8% of female escapes).

In summary, juvenile, adult male and adult female *N. oxylophus* seem to show fine-scale partitioning of perch heights and substrates. Further, escape methods seem to differ between the ages and substrates. Further, escape methods seem to differ between the ages and sexes of individuals. Different perches and escape behaviors may revolve around the different ecological and reproductive needs that juveniles and adult and females experience. Individual's size may also play a role in territory size for males and escape behavior for juveniles.

The more we understand about the behavior and distribution of *Norops* species, the better we can understand their role in the ecosystem. With the increasing concern of climate change altering the current state of ecosystems, it is vital to have specific information on individual species. This information can serve as a reference to future ecosystem changes as well as help predict ecosystem reaction to certain stimuli.

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